PATENT ABSTRACTS OF JAPAN

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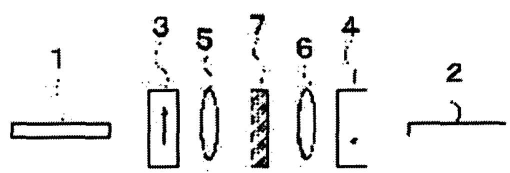
(54) OPTICAL ATTENUATOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an optical attenuator which lessens the fluctuation in the an attenuation quantity by the polarization state of incident light.

SOLUTION: This optical attenuator is constituted by arraying a first optical fiber 1, a first polarized light separating element 3 for separating or synthesizing the two linearly polarized light rays intersecting in the polarizer directions orthogonally with each other while maintaining the ray directions thereof in parallel, a first lens 5 for a collimator or image formation, a magneto-optical element group 7 combined with one or plural sheets of magneto-optical elements, a second lens 6 for convergence, a second polarized light separating element 4 for separating or synthesizing the two linearly polarized light rays intersecting in the polarizer directions orthogonally with each other while maintaining the ray directions thereof in parallel, and a second optical fiber 2 in this order and is constituted in such a manner that the light emitted from the first optical fiber 1 is separated to two rays of the linearly polarized light intersecting in the polarizer directions orthogonally with each other and is then bent in the progressing direction by the first optical fiber 1 and is transmitted through nearly the same point as the magneto-optical element group 7.



LEGAL STATUS

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CLAIMS

[Claim(s)]
[Claim 1] The 1st polarization separation element separated or compounded, keeping parallel the direction of a beam of light of the two linearly polarized lights where the 1st optical fiber and polarization direction intersect perpendicularly mutually, The 1st lens for the object for collimators, or image formation, and the magneto-optics elements which combined the magneto-optics element of one sheet or two or more sheets, The 2nd polarization separation element separated or compounded, keeping parallel the direction of a beam of light of the two linearly polarized lights where the 2nd lens and polarization direction for convergence intersect perpendicularly mutually, Come to arrange the 2nd optical fiber in this order, and the impression means of the external magnetic field to the aforementioned magneto-optics elements The impression means of a regular magnetic field, The light which was constituted by magnetic-field-strength adjustable magnetic field impression means to intersect perpendicularly with the aforementioned regular magnetic field mostly, and came out of the 1st optical fiber of the above by the polarization separation element of the above 1st The optical attenuator characterized by bending travelling direction with the 1st lens of the above, crossing in the position of the aforementioned magneto-optics elements, and penetrating the almost same point of the aforementioned magneto-optics elements after separating into the beam of light of the two linearly polarized lights with which the polarization direction intersects perpendicularly mutually.
[Claim 2] The optical attenuator according to claim 1 to which the direction of the polarization separation by the above 1st and the 2nd polarization separation element is characterized by being an opposite direction mostly.
[Claim 3] The claim 1 characterized by making mostly the interval between the principal planes of the above 1st and the 2nd lens into the sum of both focal distance, or an optical attenuator given in two.
[Claim 4] It is an attenuator the claim 1 which the impression means of the aforementioned regular magnetic field is a permanent magnet, and is characterized by an aforementioned magnetic-field-strength adjustable magnetic field impression means being an electromagnet, or given in three.
[Claim 5] The claim 1 characterized by the Faraday-rotation angle of the aforementioned magneto-optics elements in case the intensity of the adjustable magnetic field which intersects perpendicularly with the aforementioned regular magnetic field mostly is zero being pi/2 rads or more, or an optical attenuator given in four.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the optical attenuator which comes especially to have the Faraday-rotation child who contains the suitable magneto optics crystal for an amendment's for the amplification factor in each wavelength in the optical fiber amplifier for wavelength multiplex with respect to the optical attenuator which is made to decrease optical intensity and is adjusted mainly in optical-communication equipment or optical-information-processing equipment.
[0002]
[Description of the Prior Art] Conventionally, the optical attenuator using the magneto optics crystal has the typical composition described in a open patent official report and common [06-051255 (optical attenuator)]. The example is described in drawing 8 and drawing 9 . First, in the 1st example, as shown in drawing 8 , the light beam 81 which is the linearly polarized light which the magnetic field is impressed to the sense which intersects perpendicularly with a magneto optics crystal 83 mutually with a permanent magnet 84 and an electromagnet 85, and is penetrated is composition which carries out incidence to a polarizer 82, after receiving Faraday rotation by the aforementioned magneto optics crystal 83.
[0003] Although magnetic saturation of the aforementioned magneto optics crystal 83 is always carried out to the transmitted light by the impression magnetic field which the permanent magnet 84 of the same direction generates, the impression magnetic field generated from the electromagnet 85 controlled by the source 86 of a good transformation style by the sense with the still more nearly perpendicular transmitted light exists. Consequently, the sense of total of an impression magnetic field will shift from the sense which a light beam 81 penetrates, and a Faraday-rotation angle changes. The quantity of light of the light beam 81 after this penetrates a polarizer 82 can be arbitrarily controlled by the above-mentioned source 86 of a good transformation style, and can constitute an optical attenuator.
[0004] By the way, by the method of performing only magnetic field impression by the electromagnet of the transmitted light and the same direction, function sufficient, as an optical attenuator cannot be demonstrated without using a permanent magnet 84. This is because bismuth substitution gadolinium iron garnet (GdBi) 3(FeAlGa)5O12 which are a magnetic garnet crystal as a magneto optics crystal 83 are used, and since it generally has a powerful hysteresis, these crystals are for the impressed external magnetic field and the relation of the Faraday-rotation angle which this produces not to become settled uniquely in the state of unsaturation. Then, the external magnetic field more than a fixed size is always impressed to these magneto optics crystals, and carried out magnetic saturation to them, and the method of controlling a Faraday-rotation angle by changing the size of the external magnetic field which intersects perpendicularly on it was developed. This composition is the content of invention of an optical attenuator given [this] in an official report.
[0005] In the 1st above-mentioned example, it is the requisite that the light beam which carries out incidence is the linearly polarized light in which the polarization direction became settled. When it is in

the polarization states where an incident-light beam is arbitrary, the magnitude of attenuation changes according to the polarization state. The 2nd example described the above-mentioned open patent official report and common [06-051255] is an optical attenuator of non-dependence [polarization] so to speak which attenuation by the polarization state does not produce, even if incident lights are arbitrary polarization. This example is shown in drawing 9 .
[0006] In this drawing 9 , it is condensed with a lens 93, and the light beam 98 in the arbitrary polarization states which carried out outgoing radiation from the optical fiber 91 serves as parallel light, and carries out incidence to the taper-like birefringence crystal 95. Then, after separating into the linearly polarized light of two components which intersect perpendicularly mutually and penetrating the Faraday-rotation child 97, the taper-like birefringence crystal 96 and a lens 94 are penetrated in order, it is condensed, an optical fiber 92 is reached, and it is again compounded by one light beam.
[0007] Here, by being equivalent to the thing synthesizing the magneto optics crystal 83 in the 1st example of the above, the permanent magnet 84, the electromagnet 85, and the source 86 of a good transformation style, and operating the source 86 of a good transformation style, the Faraday-rotation child 97 controls the Faraday-rotation angle, and changes the rate of the transmitted light combined with an optical fiber 92. When this transmitted light serves as the maximum, except for the transmission loss of each optical element, or joint loss of optical system, two polarization components of the transmitted light reach an optical fiber 92, and, unlike the 1st example of the above, do not receive attenuation resulting from the polarization state of an incident light.
[0008]
[Problem(s) to be Solved by the Invention] In the 2nd example the above-mentioned open patent official report shown in drawing 9 , and common [06-051255], after separating into the linearly polarized light of two components which intersect perpendicularly mutually in the taper-like birefringence crystal 95, incidence of the light beam 98 which are the arbitrary polarization which carried out outgoing radiation from the optical fiber 91 is carried out to the Faraday-rotation child 97. In this case, in case the magneto optics crystal which constitutes the Faraday-rotation child 97 is penetrated, as shown also in drawing 9 , the light beam of two kinds of linearly polarized lights by which polarization separation was carried out will penetrate the position generally left mutually.
[0009] By the way, when impressing the magnetic field of the 2-way which intersects perpendicularly with the magneto optics crystal which constitutes a Faraday-rotation child mutually and changing the magnetization direction, the difference of a property arises in the magneto-optical effect which two kinds of linearly polarized lights by which it becomes impossible to have disregarded dispersion by the place of the Faraday-rotation angle over the transmitted light, and polarization separation was carried out as a result receive, respectively.
[0010] An example of dispersion by the place of the Faraday-rotation angle in the magneto optics crystal generally used for drawing 4 to an optical attenuator is shown. It is what performed this measurement to the transmitted light and the same direction by passing 50mA current on this electromagnet using the permanent magnet which carries out magnetic field impression, and the electromagnet which impresses a magnetic field in the direction which intersects perpendicularly to the transmitted light, and is equivalent to this current value having impressed the magnetic field of about 500 G to the sense which intersects perpendicularly with the transmitted light. A field perpendicular to the transmitted light is 1mmx iron garnet [bismuth substitution gadolinium] [$(GdBi)_3(FeAlGa)_5O_{12}$] element which makes the square which is 1mm, the magneto optics crystal is carrying out magnetic saturation to the transmitted light and the same direction with the permanent magnet which carries out magnetic field impression, and the impression magnetic field strength is about [exceeding magnetic field strength required for the magnetic saturation of a magneto optics crystal] 250G.
[0011] The measured value shown in drawing 4 is the distribution of the measured value of the Faraday-rotation angle in the 400micrometerx400micrometer field near the center of the light-transmission side in the aforementioned magneto optics crystal. According to drawing 4 , even in near the center of a magneto optics crystal, a difference of a Faraday-rotation angle may reach 1deg in the position left 100 micrometers mutually. Although this phenomenon hardly affects it to the magnitude of attenuation of an

optical attenuator when the magnitude of attenuation is small, when the magnitude of attenuation is large, it appears as a polarization dependency of a damping property. If in other words incidence of the linearly polarized light is carried out to an optical attenuator and the plane of polarization of an incident light is rotated, it will become the phenomenon of changing the optical magnitude of attenuation sharply. Therefore, the composition of each optical element shown as the 2nd example the above-mentioned open patent official report and common [06-051255] had a problem about making small change of the magnitude of attenuation depending on polarization.

[0012] Then, this invention makes it the technical problem to offer the optical attenuator which made small change of the magnitude of attenuation resulting from the polarization state of the light which carries out incidence.

[0013]

[Means for Solving the Problem] In the example of measurement of dispersion by the place of the Faraday-rotation angle of a magneto optics crystal shown in drawing 4 , measured value is changing continuously smoothly in fact. Therefore, if two kinds of linearly polarized lights which carry out incidence to a magneto optics crystal among each optical element which constitutes an optical attenuator and by which polarization separation was carried out penetrate the position which approached very much mutually, the influence of the Faraday-rotation angle changing with places within a magneto optics crystal can be suppressed. In order to make two kinds of linearly polarized lights approach as much as possible, the composition whose linearly polarized light of two components which carry out incidence to a magneto optics crystal may penetrate the position which approached mutually is realizable by using for this order as composition between two optical fibers combining the 1st parallel monotonous birefringence crystal, the object for collimators or the lens for image formation and an independent or multiple magneto optics crystal, the lens for convergence, and the 2nd parallel monotonous birefringence crystal.

[0014] In addition, the 1st optical fiber, the 1st parallel monotonous birefringence crystal, and one lens for collimators, The one a Faraday-rotation child and one lens for convergence, the 2nd, and 3rd parallel monotonous birefringence crystals and 2nd optical fibers are arranged in this order. As an optical device to which the linearly polarized light of two components components and the polarization direction cross at right angles penetrates the almost same point in a magneto-optics element, there are a patent official report, No. 2905847, and optical-isolator equipment. However, the technical problem which this invention solved was making thickness of an expensive polarization separation element small, and was not making the linearly polarized light of two components components and the polarization direction cross at right angles penetrate at the almost same point in a magneto-optics element.

[0015] Namely, the 1st polarization separation element separated or compounded while the optical attenuator of this invention had kept parallel the direction of a beam of light of the two linearly polarized lights where the 1st optical fiber and polarization direction intersect perpendicularly mutually, The 1st lens for the object for collimators, or image formation, and the magneto-optics elements which combined the magneto-optics element of one sheet or two or more sheets, The 2nd polarization separation element separated or compounded, keeping parallel the direction of a beam of light of the two linearly polarized lights where the 2nd lens and polarization direction for convergence intersect perpendicularly mutually, Come to arrange the 2nd optical fiber in this order, and the impression means of the external magnetic field to the aforementioned magneto-optics elements The impression means of a regular magnetic field, The light which was constituted by magnetic-field-strength adjustable magnetic field impression means to intersect perpendicularly with the aforementioned regular magnetic field mostly, and came out of the 1st optical fiber of the above by the polarization separation element of the above 1st After separating into the beam of light of the two linearly polarized lights with which the polarization direction intersects perpendicularly mutually, it is bent with the 1st lens of the above, crosses in the position of the aforementioned magneto-optics elements, and is characterized by penetrating the almost same point of the aforementioned magneto-optics elements.

[0016] Moreover, the optical attenuator of this invention can be mostly constituted to an opposite direction by carrying out the direction of the polarization separation by the above 1st and the 2nd

polarization separation element.
[0017] Furthermore, the optical attenuator of this invention can make the interval between the principal planes of the above 1st and the 2nd lens the composition mostly made into the sum of both focal distance.
[0018] Moreover, the impression means of the aforementioned regular magnetic field of the optical attenuator of this invention is a permanent magnet, and let an aforementioned magnetic-field-strength adjustable magnetic field impression means be an electromagnet.
[0019] Furthermore, the optical attenuator of this invention can take the large adjustable range of the magnitude of attenuation by setting to pi/2 rads or more the Faraday-rotation angle of the aforementioned magneto-optics elements in case the intensity of the adjustable magnetic field which intersects perpendicularly with the aforementioned regular magnetic field mostly is zero.
[0020]
[Embodiments of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.
[0021] Drawing 1 is the typical side elevation having shown an example of the arrangement composition of each optical element in the optical attenuator of this invention. In this drawing, the arrow in the parallel monotonous birefringence crystals 3 and 4 shows the direction which the beam of light of unusual light separates from Tsunemitsu's beam of light. That is, the separation direction in the parallel monotonous birefringence crystal 3 is above, and the separation direction in the parallel monotonous birefringence crystal 4 is down. And the width of face of those separation is equal.
[0022] Drawing 2 shows behavior of the polarization beam of two components in the optical attenuator shown in drawing 1 which intersect perpendicularly. In drawing 2 , the parallel monotonous birefringence crystals 3 and 4 are bearing the role which separates or compounds a light beam to the linearly polarized light of two components which intersect perpendicularly mutually. Moreover, the 1st lens 3 bears the operation which the operation which changes the light which carried out outgoing radiation into the operation or parallel light which carries out image formation from the 1st optical fiber 1 is borne [operation], and makes two polarization which intersects perpendicularly cross mostly in the position of a magneto optics crystal 7.
[0023] Drawing 2 (a) shows behavior of two polarization component beams in case the magnitude of attenuation serves as the minimum. The joint optical system which prepared two lenses between the 1st optical fiber 1 and the 2nd optical fiber 2 in which light comes out of and carries out incidence consists of this operation gestalt, and the transmitted light condenses to the end face of the 2nd optical fiber 2, and carries out incidence into this fiber. Although both the linearly polarized lights cross mutually after separating the light beam which carried out outgoing radiation into the linearly polarized light of two components which intersect perpendicularly mutually as the parallel monotonous birefringence crystal 3 first from the 1st optical fiber 1 and penetrating a lens 5, a magneto optics crystal 7 is arranged in the intersection position. And by the magneto optics crystal 7, the linearly polarized light of two components which received about pi/2 Faraday rotation is changed into convergence light with a lens 6, penetrates the parallel monotonous birefringence crystal 4, is again compounded by the single light beam, and reaches the end face of an optical fiber via an optical path 8.
[0024] Drawing 2 (b) shows behavior of two polarization component beams in case the magnitude of attenuation becomes the maximum. In this case, as a result of Faraday rotation by the magneto optics crystal 7 being about 0, similarly the light beam which passed the parallel monotonous birefringence crystal 3 as an unusual light passes the parallel monotonous birefringence crystal 4 as an unusual light. Moreover, similarly the light beam which passed the parallel monotonous birefringence crystal 3 as Tsunemitsu passes the parallel monotonous birefringence crystal 4 as Tsunemitsu. The optical path at that time is shown by 9 and 10, and is not combined with the 2nd optical fiber 2.
[0025] Next, operating state in case the middle magnitude of attenuation is obtained is explained. In a magneto optics crystal 7, the linearly polarized light of two components which intersect perpendicularly receives Faraday rotation exceeding pi/2 rad at the time of the maximum, respectively. When the sense of the magnetic field impressed to a magneto optics crystal 7 is leaned from a light transmission, a

Faraday-rotation angle decreases and which polarization direction of Tsunemitsu of the parallel monotonous birefringence crystal 4 and unusual light stops and corresponding. [the polarization direction's of the two linearly polarized lights which carry out incidence to the parallel monotonous birefringence crystal 4] Consequently, polarization separation arises in each linearly polarized light which carried out incidence, and the path of the light beam after penetrating the parallel monotonous birefringence crystal 4 becomes three kinds of the optical path 8 of drawing 2 (a), and the optical paths 9 and 10 of drawing 2 (b). Among these, only what passed the optical path 8 combines with the 2nd optical fiber 2.

[0026] By the way, if a Faraday-rotation angle can be changed to zero to pi/2 rad, the large adjustable range of the magnitude of attenuation can be taken. However, in fact, even if it strengthens the magnetic field by the electromagnet, it is not easy to make the travelling direction and the magnetization direction of light intersect perpendicularly. Consequently, a Faraday-rotation angle does not become zero but the large magnitude of attenuation can be taken. Then, even if the polarization separation direction of a polarization separation element and the polarization direction of light shift for a while, the loss by it notes not being not much large. And means to make the minimum value of the magnitude of attenuation into a sacrifice a little, and to secure the maximum of the magnitude of attenuation are taken. For that purpose, I hope that a Faraday-rotation angle is made larger than pi/2 rad, and the polarization separation direction of two polarization separation elements can be shifted from pirad. Before a Faraday-rotation angle becomes zero when are done so and a part for the gap and a Faraday-rotation angle are in agreement namely, the magnitude of attenuation can be made into the maximum.

[0027] Moreover, parallel monotonous 1 axial birefringence crystal which leaned the optical axis (the direction of a crystallographic axis where Tsunemitsu and the rate of an unusual optical refraction become equal) from the beam of light is useful as the 1st and 2nd polarization separation elements. However, the artificial birefringence matter not only with this but a periodic refractive-index distribution can also be used.

[0028] Furthermore, as joint optical system, the confocal system which makes distance between the principal planes of the 1st and the 2nd lens the sum of the focal distance of those lenses is useful. If it does so, the large tolerance to the position gap at the time of assembly can be taken. Moreover, if a TEC (core expansion) fiber is used for an optical fiber, spot size in the center section between lenses can be made small, and optical system with the tolerance big moreover to a position gap can be obtained.

[0029]

[Example] Next, an example explains this invention in detail.

[0030] The structure inside the case of the optical attenuator which is one example of this invention is shown in drawing 3 . This drawing shows the cross section cut in the level surface containing the optical path of the transmitted light. Bismuth substitution gadolinium iron garnet [(GdBi)3(FeAlGa)5O12] is arranged as the rutile crystals 31 and 34 and a magneto-optics element 39 as the lenses 35 and 36 for condensing, and an parallel monotonous birefringence crystal, respectively on the optical path between the optical fibers 31 and 32 attached in right and left of a case 42. In addition, magnetic saturation of this garnet is carried out with permanent magnets 37 and 38. Moreover, the yoke pillar 40 for impressing an adjustable magnetic field is installed in the direction which intersects perpendicularly with an optical path, and the hundreds turn ******** coil 41 is further arranged for lead wire at the circumference. Arrangement of each above-mentioned optical element is the same composition as fundamentally as an example of the arrangement composition of an optical element shown in drawing 1 , and all the effective incidence fields of the transmitted light of each optical element are set to 1.0x1.0mm.

[0031] The Faraday-rotation angle of bismuth substitution gadolinium iron garnet 39 is set to pi/2 rads or more when the magnetic field strength produced from the yoke pillar 40 is zero. Although this garnet is produced by the solution layer epitaxial method, in the case of the element corresponding to the light wave length field to which an optical attenuator is used, by this method, only the element of the thickness from which an about one-rad Faraday-rotation angle is acquired at the maximum is unproducible in the present condition. Then, the method of considering as the composition which can acquire a Faraday-rotation angle pi/2 rads or more in total by sticking the element of two or more sheets,

or arranging and arranging in the direction of a light transmission is common. However, in the optical attenuator of this example, in order to avoid the optical damage of the front face of this garnet, the bismuth substitution gadolinium iron garnet of two or more sheets is fixed by the way adhesives do not intervene in an optical-path side. That is, it is fixed with a electrode holder and solder.

[0032] On the other hand, each rutile parallel plate and each lens are set up so that the transmission loss to the optical fiber of the transmitted light may become [the magnetic field strength similarly produced from a yoke pillar] the minimum in the state of zero. That is, about the rutile parallel plate, the separation direction of the unusual light is reverse, about the lens, a lens uses the lens of the same kind and the optical fiber also uses the thing of the same kind. And if current is added to the coil line coiled around the bobbin and the value is made to increase, the adjustable magnetic field impressed with a yoke pillar increases, according to it, the Faraday-rotation angle in this garnet will decrease gradually, and joint loss of the light beam to an optical fiber will increase it. In other words, the transparency magnitude of attenuation increases.

[0033] In the optical attenuator produced as mentioned above, it measured about the relation between the impressed current, the current which the magnitude of attenuation of an optical attenuator was [current] related and impressed, and the polarization dependency of the magnitude of attenuation of an optical attenuator. With the measurement result of the optical attenuator (the conventional example is called hereafter) using the taper type rutile board shown by drawing 9 , the result was shown in drawing 5 and drawing 6 . Moreover, drawing 7 is drawing showing the relation between the current passed on the electromagnet in an optical attenuator, and the magnetic field strength actually generated with the electromagnet. This relation is [both] the same on the both sides of the example of the optical attenuator in this invention, and the conventional example. In addition, in the example and the conventional example of an optical attenuator in this invention, the bismuth substitution gadolinium iron garnet of the same composition is used as a magneto optics crystal as aforementioned, and both the impression magnetic field strength of the permanent magnet impressed for magnetic saturation is also the same conditions as about 250 G.

[0034] According to drawing 5 , the property of the magnitude of attenuation to the current to impress can be said to be almost equivalent in this example and the conventional example. Next, this example is compared with the conventional example about the polarization dependency of the magnitude of attenuation using drawing 6 . The vertical axis of this drawing shows PDL (polarization dependency loss, Polarization Dependent Loss). Here, PDL is the difference of the maximum magnitude of attenuation when changing the polarization state of an incident light so that all the points on the Poincare sphere may be taken, and the minimum magnitude of attenuation. According to this drawing, in the conventional example, although PDL (polarization dependency loss) was increasing with elevation of current, i.e., the increase in the magnitude of attenuation, in the optical attenuator by the composition of this invention, the increase in this numeric value was able to be reduced greatly. That is, to the incident light, it did not depend on the sense of the extinction ratio or plane of polarization, but the optical attenuator which can give the fixed magnitude of attenuation was able to be developed.

[0035]

[Effect of the Invention] As shown above, even if it is the case of what the magnitude of attenuation, according to this invention, change of the magnitude of attenuation resulting from polarization states, such as an extinction ratio of an incident light and sense of plane of polarization, can offer a small optical attenuator.

[Translation done.]

DESCRIPTION OF DRAWINGS

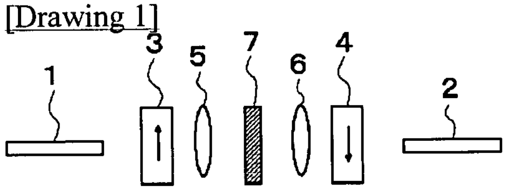
[Brief Description of the Drawings]
[Drawing 1] The typical side elevation showing the composition of the optical attenuator of this invention.
[Drawing 2] Drawing showing behavior of the transmitted light in the optical attenuator of this invention. For drawing 2 (a), drawing 2 (b) is drawing showing behavior of the transmitted light in case it is drawing showing behavior of the transmitted light in case the magnitude of attenuation is the minimum and the magnitude of attenuation is the maximum.
[Drawing 3] The ** type view showing the part arrangement inside the case of the optical attenuator of this invention.
[Drawing 4] Drawing showing an example of dispersion in an optical surface of the Faraday-rotation angle of a magneto-optics element.
[Drawing 5] Drawing showing the relation between the magnitude of attenuation and the current passed on an electromagnet.
[Drawing 6] Drawing showing the relation between PDL (polarization dependency loss) and the current passed on an electromagnet.
[Drawing 7] Drawing showing the relation between the magnetic field strength by the electromagnet, and current.
[Drawing 8] Drawing showing the structure in the 1st example of the conventional optical attenuator.
[Drawing 9] Drawing showing the conventional composition and conventional operation of the 2nd in an example of an optical attenuator.
[Description of Notations]
1 1st Optical Fiber
2 2nd Optical Fiber
3 1st Polarization Separation Element
4 2nd Polarization Separation Element
5 1st Lens
6 2nd Lens
7 Magneto-optics Element
8, 9, 10 Optical path
31 32 Optical fiber
33 34 Parallel monotonous birefringence crystal
35 36 Lens
37 38 Permanent magnet
39 Garnet
40 Yoke Pillar
41 Coil
42 Case
81 Light Beam

82 Polarizer
83 Magneto Optics Crystal
84 Permanent Magnet
85 Electromagnet
86 Source of Good Transformation Style
91 92 Optical fiber
93 94 Lens
95 96 Taper-like birefringence crystal
97 Faraday-Rotation Child
98 Light Beam

[Translation done.]

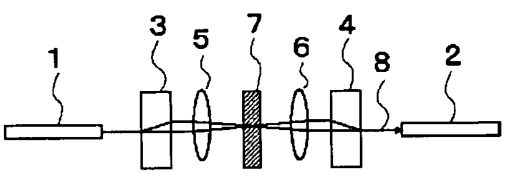
DRAWINGS

[Drawing 1]



[Drawing 2]

(a)



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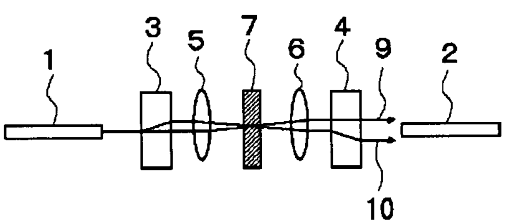
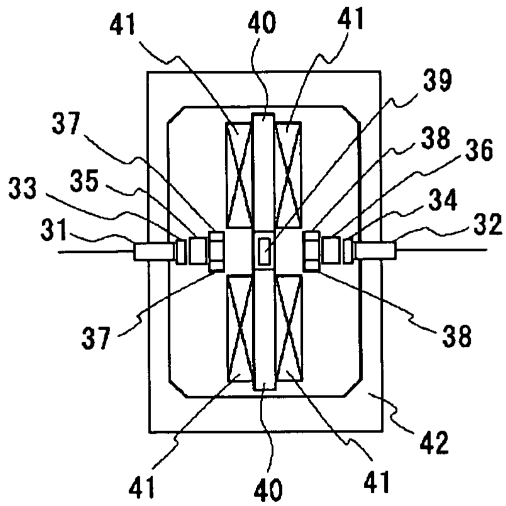
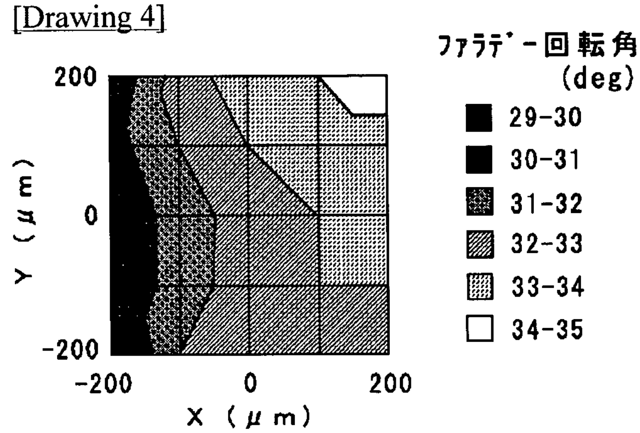


[Drawing 3]



[Drawing 4]



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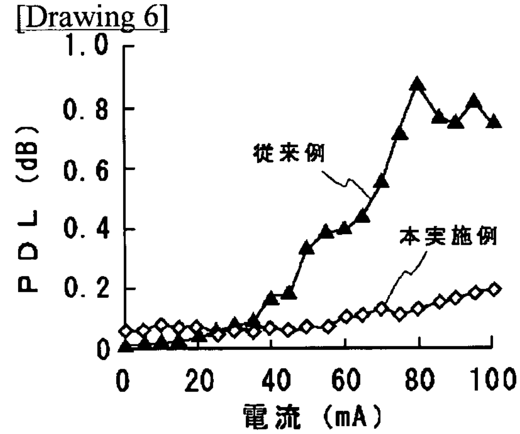
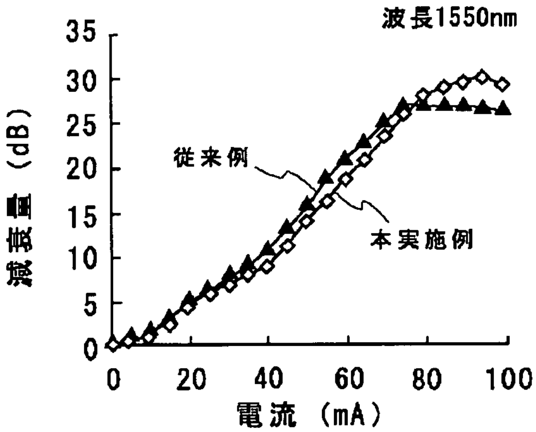
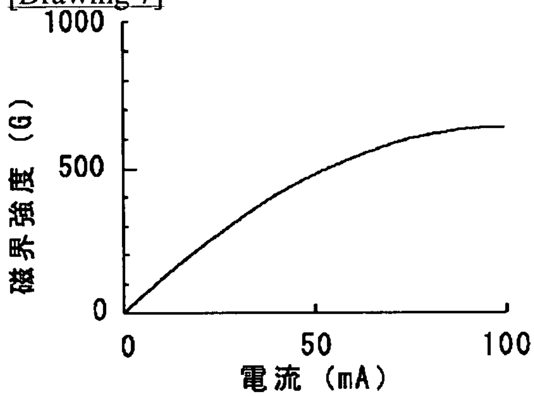


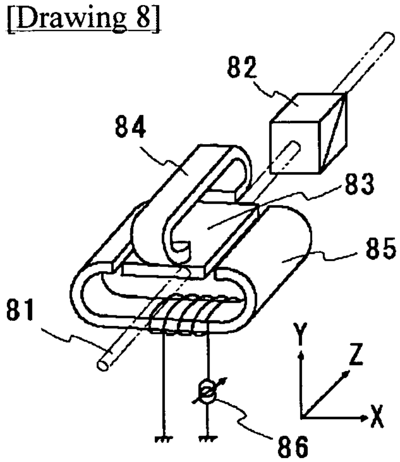
[Drawing 5]



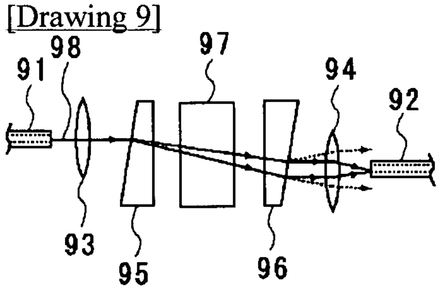
[Drawing 7]



[Drawing 8]



[Drawing 9]



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